THE BEDFORD FAUNA AT INDIAN FIELDS AND IRVINE, KENTUCKY.*

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The stratigraphic succession of the chief divisions of the Waverly in Ohio, in descending order, is:

6. Logan formation, chiefly sandstones.
5. Black Hand formation, sandstones, often coarse, and locally conglomeratic.
4. Cuyahoga formation, sandstones and clay shales.
3. Sunbury formation, fissile black shales.
2. Berea sandstone, often ripple marked.
1. Bedford clay shales, locally with sandstones.

In 1888, Mr. E. O. Ulrich, in the fourth volume of the Bulletin of Denison University, identified from the Upper Waverly of Ohio sixteen species of bryozoans which occur also in the Keokuk of Kentucky, Illinois and Iowa. Of these, eight are found at King's Mountain, Kentucky, in strata identified by Ulrich as Keokuk, and two other species are closely related to forms found at that locality. From this it is evident that the upper Waverly, now known as the Logan formation, is closely related to the strata exposed at King's Mountain, and that both are approximately equivalent to the Keokuk of the Mississippi Valley.

In a paper read before the Geological Society of America, at Baltimore, in 1908, Prof. Stuart Weller expressed the conviction that the richly fossiliferous strata exposed at the Button Mold

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Knob, seven miles south of Louisville, Kentucky, were closely related to the upper Kinderhook, as exposed in the Mississippi Valley. Since these layers at the Button Mold Knob belong to the strata known in Indiana as the New Providence shales, and since the equivalent of these strata lies at the base of the Cuyahoga section in east-central Kentucky, it is probable that those parts of the Waverly which underlie the Cuyahoga also are approximately equivalent to various parts of the Kinderhook section in the Mississippi Valley. From this standpoint, the Bedford may be regarded for the present as a lower Kinderhook horizon.

During the summer of 1908, Mr. W. C. Morse and the present writer were engaged, under the auspices of the Kentucky geological survey, in tracing the lower Waverly formations southward from the Ohio River. In the course of these investigations it became evident that even in the first county south of the river, Lewis County, the Berea lost its distinguishing feature as a series of distinct sandstones, strongly ripple marked, and no longer could be readily distinguished from the underlying Bedford.

For the attenuated part of the Bedford and Berea section, the term Bedford-Berea is employed temporarily.

In the east-central part of Kentucky, at Indian Fields and Irvine, where the Bedford-Berea section does not exceed one foot in thickness, a number of fossils have been found, and since very little is known, so far, of the paleontology of the Bedford-Berea section either in Ohio or Kentucky, the following notes are here appended.

In the fourth volume of the Bulletin of Denison University, in 1888, Prof. C. L. Herrick identified from the Bedford clay shales at Central College, Ohio, the following species:

Lingula melie.
Orbiculoidea newberryi.
Palaeoneilo bedfordensis.
Leda (=*Nuculana*) *diversa–bedfordensis*, var. nov.
Orthis (=*Rhipidomella*) *vanuxemi.*
Chonetes scitulus.
Ambocoelia umbonata.
Macrodon hamiltoniae.
Microdon (=*Cypricardella*) *bellistriatus.*
Bellerophon newberryi or *helena.*
Loxonema cf. *delphicola.*
Orthoceras cf. *linteum.*
Pleurotomaria sulcomarginata.
Goniatites cf. Portage species.
Hemipronites (=*Schuchertella*) sp.
Pterinopecten sp.
Bellerophon lineata.

Of these species, the first two appear to be characteristic of the Sunbury shale. *Lingula melie* was described from the Sunbury shale at Chagrin Falls, 16 miles east of Cleveland, and the types of *Orbiculoidea newberryi* were obtained at the same horizon befow the Cuyahoga Falls, 28 miles southeast of Cleveland. The third species in the list was published originally from the Bedford shales. The following ten species are regarded as either identical with, or closely related to various Hamilton species. The fourteenth in the list is said to resemble a Portage species. No comparisons are made in case of the next two. It is evident that Prof. Herrick was strongly influenced in his identifications by the belief that the Bedford presented an upper Devonian rather than a lower Carboniferous fauna.

In the first volume of the Geology of Ohio, on page 189, Prof. Newberry listed as coming from the Bedford shale, at Bedford, Ohio, *Syringothyris typa* (=*carteri*), *Rhynchonella* (=*Camarotoechia*) *sageriana*, *Orthis* (*Rhipidomella*) *michelini*, *Spiriferina solidirostris*, and *Macrodon hamiltoniae*. From this it is evident that Newberry was impressed with the Waverly affinities of the Bedford. In the second volume of the Geology of Ohio, Newberry listed from the Bedford shale also *Hemipronites crenistria*, *Chonetes logani*, and *Lingula cuyahoga*. In the seventh volume of the Geology of Ohio, Prof. C. L. Herrick expressed the opinion that the fossils listed by Newberry "do not occur in the typical shaly Bedford, but in thin flags associated or interbedded, while the typical Bedford, especially in central Ohio where it reposes directly upon the "Black Shale," carries a considerable series of fossils forming a decided Devonian assemblage. More remarkable still, the specific resemblances are unquestionably with Hamilton (in the broad sense) rather than the Chemung fauna."

In the attempt to determine the equivalence, approximately, of the Bedford shale to horizons already known elsewhere, the resemblances rather than the differences of the Bedford fauna to other species were noted. The result is that the fauna of the Bedford is still, practically, an unworked field. In the hope of contributing at least a little to our knowledge of the Bedford fauna, the following notes are added. They consist of descriptions of the various forms discovered so far in the attenuated representatives of the Bedford–Berea section, as exposed at Indian Fields and Irvine, Kentucky. For the stratigraphy the reader is referred to the paper on the Waverly formations of east-central Kentucky published by W. C. Morse and A. F. Foerste in the Journal of Geology, March, 1909, page 164.

Lingula irvinensis, sp. nov. (Fig. 7).

Valves gently convex. Concentric striae very fine and close together; of these, 5 or 6 in a length of 2 mm. appear slightly more prominent than the others. Length, 4.8 mm.; width, 4 mm.

Compared with *Lingula melie*, this species is distinctly broader and more oval in form; moreover, all specimens found so far are considerably smaller. Compared with *Lingula meeki* Herrick, the shell is distinctly smaller, the beak is less prominent, appears less attenuated, and the horizon is considerably lower. Rare in the thin representative of the Bedford–Berea at Irvine, Kentucky.

Orbiculoidea sp. (Fig. 12). Compared with *Orbiculoidea newberryi* the apex of the brachial valve appears to be nearer the center; and the pedicel area, though supplied with a strongly elevated, sharp, median ridge, is not supported on a distinctly elevated oval platform, as figured by Hall and Clarke (Volume VIII of the Paleontology of New York) in a typical specimen of *Orbiculoidea newberryi* obtained from the type locality, at Cuyahoga Falls, Ohio. Our shell appears to be related more closely to *Orbiculoidea herzeri*, but the apex of the brachial valve is too central. A small median striation or septum extends forward a short distance from the apex of the pedicel valve along its interior. This is probably a new species, but too imperfectly characterized as yet to receive a name. Concentric striae fine and numerous; some of them, at various intervals, more strongly elevated than others. Outline nearly circular. Lateral diameter about 8 mm. Height of the brachial valve, a little less than 3 mm. In the thin representative of the Bedford-Berea at Indian Fields, Kentucky; not rare.

Orbiculoidea sp. (Fig. 13). The apex of the brachial valve of this species is too far from the center to make it at all likely that this species is identical with the one found at Indian Fields, mentioned above. It is a smaller species apparently, and the concentric striae are less distinct. The largest specimen found has a length of 5 mm. In the thin representative of the Bedford–Berea at Irvine, Kentucky.

Schuchertella morsei, sp. nov. (Fig. 1).

Species of persistently small size. Valves transversely elongate, with the greatest width at the hinge-line. Pedicel valve with a high cardinal area and a prominent deltidium; surface sloping rather evenly from the beak to the margins of the shell, but appearing convex owing to the elevation of the beak. Brachial valve either flat or slightly concave, usually elevated at the beak into a tiny knob. Radiating striae 25 to 30, of which only the alternate striae may be considered as primary, although some of the secondary striae originate near the beak; radiating striae narrow, with wide interspaces, crossed by finer concentric lines, visible only under a lens. Length, 2.6 mm.; width 4.5 mm.; elevation of cardinal area 1 mm.

Abundant in the thin representative of the Bedford–Berea in the northeastern part of Irvine, Kentucky; rare at the same horizon northeast of Indian Fields, Kentucky. Named in honor of Mr. W. C. Morse, in whose delightful companionship the

stratigraphy of the Lower Waverly of Kentucky was unravelled. *Schuchertella morsei* is closely related to *Orthothetes minutus*, Clarke, from the lower limestone in the Marcellus shales of New York, and may be a diminutive descendant of *Streptorhynchus flabellum*, Whitfield, from the Columbus limestone of Ohio. Its relations to *Orthothetes minutus*, Cummings, from the Salem limestone of Indiana, are less evident. Septa and dental plates are absent in the pedicel valve, the hinge area is rather high, but the beak is not distorted and there is no evidence of attachment of the shell by cementation.

Schuchertella herricki, sp. nov. (Fig. 16).

Shell usually transversely elongate, but sometimes attaining a length which is almost as great as the width. The valves were thin and are preserved as strongly flattened specimens which suggest that originally the brachial valve was gently convex and the pedicel valve either flat or slightly concave. In one pedicel valve the arching deltidium and the moderately elevated cardinal area are preserved. The casts of the brachial valve show the impressions made by the crural plates, the posterior border of the flattened cardinal process, and a trace of a median ridge traversing the space occupied by the muscular impressions. Radiating striae narrow and numerous, varying between 5 and 7 in a width of 2 mm., counting both the more prominent striae and those which evidently have been intercalated later. While the difference in size of the radiating striae is readily perceptible under a lens, they appear subequal to the unaided eye. Concentric striae very fine and visible only under a lens. Width of an average specimen, 22 mm.; length, 16 mm.; height of cardinal area, a little over 1 mm.

Abundant in the thin representative of the Bedford–Berea about a mile northeast of Indian Fields, Kentucky, along the road running from the Brownlow Bruner farm on Lulbegrud Creek northwestward toward Kiddville. Named in honor of Prof. C. L. Herrick, whose investigations, on the Paleontology of the Waverly of Ohio contributed materially to our knowledge.

Chonetes sp. (Fig. 10).

A small species, 6.2 mm. in width and 4.5 mm. in length, with 5 to 6 radiating striations in a width of 1 mm. In one specimen, a narrow median striation extends along the base of a narrow median groove from near the beak to within a short distance of the anterior margin of the shell, somewhat resembling a figure of *Chonetes coronata*, published by Hall and Clarke (Volume VIII, Paleontology of New York). Traces of the brachial ridges may be seen, but not enough is known for identification.

In the thin representative of the Bedford–Berea at Indian Fields, Kentucky. Apparently the same species is found in the corresponding layer at Irvine, Kentucky.

Productella sp. Very much flattened impressions of the interiors of the brachial valves of a small species of *Productella*, usually not over 8 mm. in length are not uncommon in the thin representative of the Bedford–Berea at Indian Fields, Kentucky. Much smaller specimens, not exceeding 2.5 mm. in length, found at the same horizon at Irvine, Kentucky, may belong to the genus *Strophalosia*.

Syringothyris sp. A specimen with a short hinge line, as in *Syringothyris typa*, but presenting only the hinge area of the pedicel valve and a few of the immediately adjacent parts of the radiating plications, was found at Indian Fields, in the thin representative of the Bedford–Berea. *Syringothyris typa* is listed by both Newberry and Schuchert from the Bedford shales at Bedford, Ohio.

Ambocoelia norwoodi, sp. nov. (Fig. 2).

Pedicel valve much less arched than in most specimens referred to this genus, although it is not known how much of this may be due to flattening. The beak and umbonal parts projects less conspicuously beyond the hinge line. The median depression is reduced to a narrow groove and widens very little anteriorly. The brachial valve is gently convex; the median depression, narrow near the beak, widens considerably anteriorly, though remaining comparatively shallow. Concentric lines rather inconspicuous. Length of fairly large specimens, 5 mm.; width about the same.

Rather common in the thin representative of the Bedford-Berea at Irvine, Kentucky. Named in honor of Prof. C. J. Norwood, State Geologist of Kentucky, who for many years has been keenly interested in the correllation of the various Mississippian strata of Kentucky.

Camarotoechia kentuckiensis, sp. nov. (Fig. 14).

Sinus of the pedicel valve and the elevated fold of the brachial valve almost imperceptible in most of the specimens at hand. As a rule, the radiating plications occupying these parts of the shell appear slightly narrower and closer together than those lateral plications which occur within a short distance of the latter. Three plications occur in the sinus and four on the fold. The total number of plications is about 16. The slender vertical lamellae supporting the teeth extend well into the interior of the pedicel valve. The presence of a median septum is distinctly shown in casts of the brachial valve. but the evidence of an elongate, narrow, median cavity immediately anterior to the beak is met only occasionally. The largest specimens found so far have a length of about 10 mm. Judging from the flattened valves and the little depth of the sinus of the pedicel valve in our specimens, this species must originally have been one of only moderate convexity.

Rather common in the thin representative of the Bedford–Berea at Indian Fields, Kentucky. Compared with *Camarotoechia marshallensis*, Winchell, this species is flatter, and with a less elevated fold. The beak of the pedicel valves in normal specimens is more elongate.

Camarotoechia sp. (Fig. 11).

A single brachial valve, 16 mm. in length, with 6 plications on the median fold, only slightly elevated above the lateral plications on either side. The number of lateral plications on each side appears to be about four or five. Shells of this type usually are referred to *Camarotoechia sappho*, but in our specimen the plications appear flatter and broader, especially along the fold.

Thin representative of the Bedford–Berea at Indian Fields, Kentucky.

Cypricardella (*Microdon*) sp. (Fig. 4). The outline anterior to the beak is not concave and there is no distinct evidence of an umbonal ridge extending diagonally across the shell as in most specimens referred to this genus; nevertheless, the generic reference is believed to be correct. A small triangular tooth is found at the beak. Both right and left valves, always much flattened, have been found in the thin representative of the Bedford–Berea at Indian Fields, Kentucky. The shell apparently was almost smooth.

Cypricardella (*Microdon*) sp. (Fig. 5). In case of the specimen figured, the outline anterior to the beak is distinctly concave, there is a distinct small triangular tooth at the beak, and posteriorly there is an impression resembling a muscular area which is not found in other specimens evidently belonging to the same species, and whose significance is conjectural. The transversely elliptical form appears to be specific. The absence of any trace of the anterior muscular scar in this and the preceding species is noteworthy. In the thin representative of the Bedford-Berea at Indian Fields, Kentucky.

Nuculana kentuckiensis, sp. nov. (Fig. 6).

Anterior end of shell prolonged beyond the beak in such a manner as to produce a transversely oblong outline, the basal margin being comparatively straight, and the margin anterior to the beak being approximately parallel to the latter. The cardinal margin posterior to the beak concave and inclined as usual. Height of shell, about 4.5 mm.; length, anterior to the beak, about 4.5 mm.; total length, at least 10 mm., possibly a little more, the posterior extremity not being preserved in the specimen which is best preserved.

In the thin representative of the Bedford-Berea at Indian Fields, Kentucky.

Nuclana sp. (Fig. 3). This shell agrees in outline with *Nuculana diversa* of the Hamilton and *Nuculana pandoriformis*, as identified by Hall from the Cuyahoga of Newark, Ohio. A somewhat similar shell was figured by Herrick from the Bedford shale at Central College, Ohio, as *Nuculana diversa*, but it was listed as *Nuculana diversa–bedfordensis*, a new variety. In the thin representative of the Bedford-Berea at Indian Fields, Kentucky.

Macrodon hamiltoniae-irvinensis, var. nov. (Fig. 15). Our specimens belong unquestionably to the group typified by *Macrodon hamiltoniae*, but they do not attain as large a size and the radiating striae are confined to the post-umbonal slopes. Rather common in the thin representative of the Bedford–Berea at Irvine, Kentucky. A much flattened valve of a specimen of *Macrodon* from the same horizon, at Indian Fields, may belong to the same species.

Schizodus sp. (Fig. 8). The generic reference of the specimen referred to this genus is not known to be correct, the cardinal margin being imperfectly preserved. The shell has a general resemblance to *Schizodus cuneus*. In the thin representative of the Bedford-Berea at Indian Fields, Kentucky.

Another specimen of doubtful generic affinities (Fig. 9). bears some slight resemblance in outline to the species described by Hall as *Lunulicardium fragile*, but there is no trace of radiating striae and the species may belong to an entirely different group of lamellibranch shells. In the thin representative of the Bedford–Berea at Indian Fields, Kentucky.

EXPLANATION OF PLATE XXVII.

Fig. 1. *Schuchertella morsei*. A, brachial valve. B, pedicel valve. C, cardinal area of pedicel valve. D, elevation of deltidium over cardinal area. E, transverse section with pedicel valve on the right. Outline drawing indicating natural size of the specimens. Irvine, Kentucky. Bedford–Berea.

Fig. 2. *Ambocoelia norwoodi*. A, brachial valve. B, pedicel valve. C, outline of shell on lateral view. Also an outline drawing indicating the natural size of the shell. Irvine, Kentucky. Bedford–Berea.

Fig. 3. *Nuculana* sp. Right valve. Indian Fields, Kentucky. Bedford–Berea.

Fig. 4. *Cypricardella* (*Microdon*) sp. Right valve, lower anterior outline slightly restored. Size of shell indicated by central cross. Indian Fields, Kentucky. Bedford–Berea.

Fig. 5. *Cypricardella* (*Microdon*) sp. Left valve. Extreme anterior outline restored. Significance of posterior impression unknown; it is not found in other specimens. Indian Fields, Kentucky. Bedford–Berea.

Fig. 6. *Nuculana kentuckiensis*, sp. nov. Right valve, posterior extremity restored. Indian Fields. Kentucky. Bedford–Berea.

Fig. 7. *Lingula irvinensis*, with outline drawing indicating the natural size of the specimen. Irvine, Kentucky. Bedford–Berea.

Fig. 8. *Schizodus* sp. Generic reference uncertain. Right valve, cardinal outline not preserved. Indian Fields, Kentucky. Bedford–Berea.

Fig. 9. Generic reference uncertain. Left valve. Indian Fields, Kentucky. Bedford–Berea.

Fig. 10. *Chonetes* sp. Brachial valve, interior, natural size indicated by outline drawing. Indian Fields, Kentucky. Bedford–Berea.

Fig. 11. *Camarotoechia* sp. Cast of brachial valve with groove indicating position of median septum. Shell distorted. Six plications on the low median fold. Indian Fields, Kentucky. Bedford–Berea.

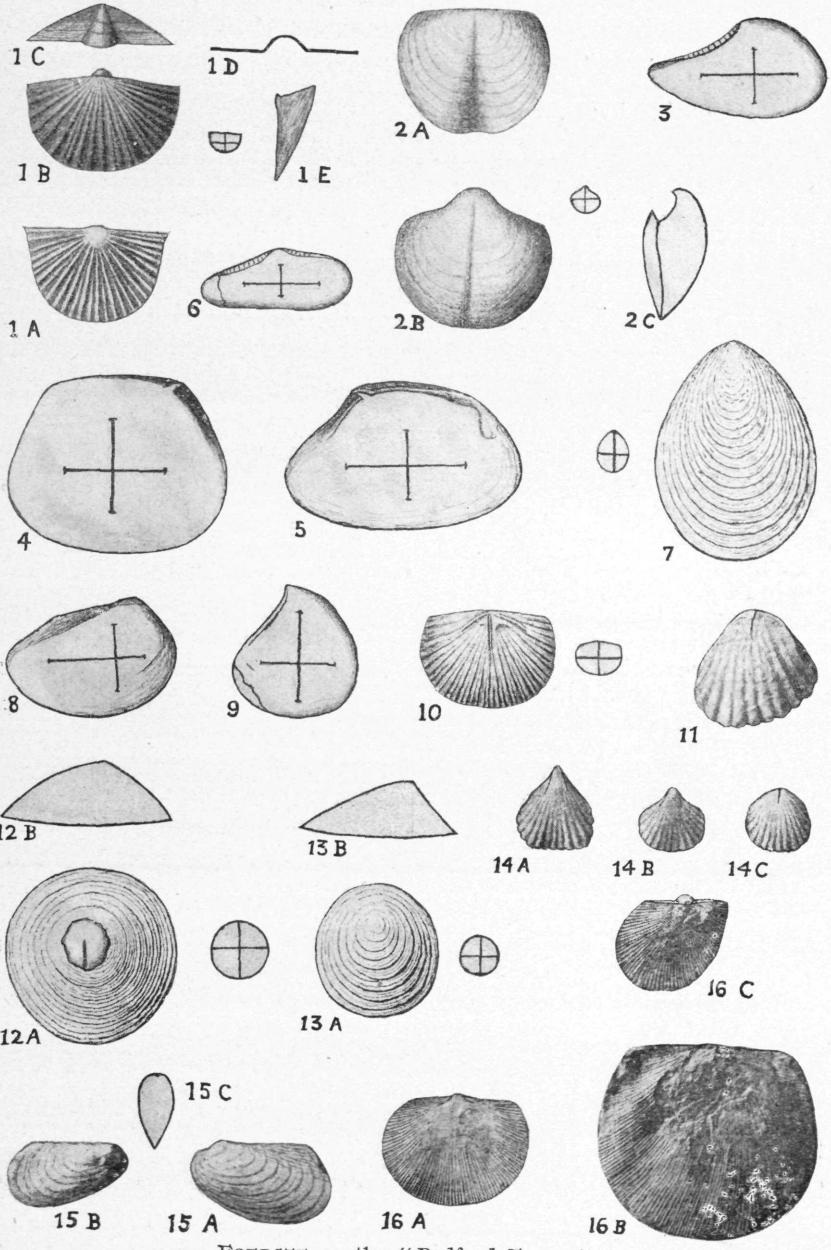
Fig. 12. *Orbiculoidea* sp. A, brachial valve, with the impression of the interior at the apical end. B, outline of valve on lateral view. Outline drawing indicating the natural size of the valve. Indian Fields, Kentucky. Bedford–Berea.

Fig. 13. *Orbiculoidea* sp. Corresponding drawings of a species found at Irvine, Kentucky. Bedford–Berea.

Fig. 14. *Camarotoechia kentuckiensis*. A, B, pedicel valves. C, brachial valve. All casts of interiors. Indian Fields, Kentucky. Bedford–Berea.

Fig. 15. *Macrodon- hamiltoniae- irvinensis*. A, left valve. B, right valve. C, outline drawing to indicate the convexity of the shell. Irvine, Kentucky. Bedford–Berea.

Fig. 16. *Schuchertella herricki*. A, B, brachial valves. C, pedicel valve, showing the cardinal area and deltidium; specimen distorted. Indian Fields, Kentucky. Bedford–Berea.



FOERSTE on the "Bedford Fauna."